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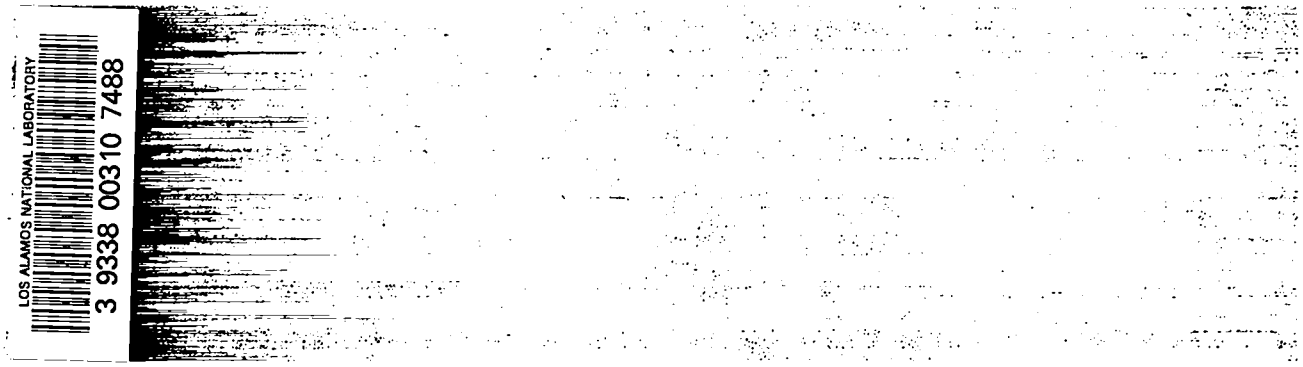

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March 19, 1951 Series A LA-1224

THE DENSITIES OF LIQUID TRITIUM, 20.6° TO 29° K(1)

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Report written by:

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(1) This paper is based on work performed under University of California contract with the Atomic Energy Commission.

Physics

PHYSICS

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THE DENSITIES OF LIQUID TRITIUM, 20.6° TO 29° K

Abstract

Most of a 70 cc (STP) sample of tritium (containing 2.0% HT) was liquefied in a Pyrex bulb of 58 mm^3 capacity between two fixed marks. The amount of gas used for this filling gave the difference between liquid and gas density. The results were corrected for gas density and for the presence of HT.

THE TRITIUM SAMPLE

For this work 70 cc (STP) of tritium was used. The source, purification, and storage have been described elsewhere.[2] The gas used

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[2] E. R. Grilly, J. Am. Chem. Soc. 73, 843 (1951).

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in the present work contained 2.0% HT and negligible amounts of other constituents, such as H_2, air, and tritocarbons, all determined mass spectrometrically.

THE APPARATUS

This was essentially the same as that used in the vapor pressure measurements.[2] In addition, there were provisions for measuring accurately the amounts of gas and of liquid. For the former, the gas was kept under constant volume, constant temperature, and variable pressure, or approximately 255 cc, 25° C, and 0 to 230 mmHg, respectively. The Pyrex liquid bulb consisted of a 17 mm length of 2 mm I.D. tubing, above and below which were regions narrowed down to 0.4 mm I.D. Inked reference marks for the liquid levels, "empty" and "full," were put on the narrow regions. The bulb was observed through a traveling microscope. The bulb volume was calibrated with liquid hydrogen at 19.5° K, the average of six determinations giving a volume of 57.80 mm^3 with a mean deviation of $\pm$ 0.06%. Volume determinations were also made between 14° and 22.8°, but no consistent variation was observed. The liquid hydrogen molar volumes below 20.4° were taken from Scott and

Brickwedde,[3] and those above 20.4°, from Woolley, Scott, and Brickwedde,[4]

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[3] R. B. Scott and F. G. Brickwedde, J. Research Natl. Bur. Standards, 19, 237 (1937).

[4] H. W. Woolley, R. B. Scott, and F. G. Brickwedde, ibid., 41, 379-475 (1948).

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who recomputed the results of Mathias, Crommelin, and Onnes.[5] At 19.500° K the value used was 28.021 cc/mole.

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[5] E. Mathias, C. A. Crommelin, and H. Kamerlingh Onnes, Comm. Leiden, 154b (1921).

PROCEDURE

The Toepler pump was used to transfer low-pressure gas into the condensing tube so that the liquid level just came to the bottom mark. The amount of gas left on the other side of the pump was measured by noting the pressure. More gas was liquefied until the upper mark was reached. Bulb immersion in the bath was kept 1 cm above the mark by raising the dewar. Again the amount of gas left was measured. The amount of gas (in moles) used to fill the liquid bulb divided by the bulb volume (between the marks) gives the difference between liquid and gas densities. The gas densities were calculated as previously[2] and amounted to a maximum correction of 3.6%. To make a slight (0.3%) correction for the

2.0% HT, linearity between mole fraction and molar volume was assumed, and the molar volume of HT was taken equal to that of D_2.

RESULTS

As a check, the density of deuterium at 19.48°K was determined (after correcting for 0.72% HD) to be 42.89 mole/liter, 0.2% higher than the result of Clusius and Bartholomé.[6]

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[6] K. Clusius and E. Bartholome, Z. physik Chem. [B] 30, 237 (1935).

Table I gives the tritium results as follows: the direct measurements on liquid density minus gas density, the calculated gas densities; the liquid densities after correcting for 2.0% HT; the deviations of the final densities from a smooth curve. Table II gives smoothed tritium densities at several temperatures, from the triple point to 29°K.

TABLE I

MOLAR DENSITIES OF LIQUID TRITIUM

T (°K)	ρ_{liq} (mole/liter)	ρ_{gas} (a)	ρ_{gas}	ρ_{liq} (b)	Dev. from curve
20.61	45.17		0.13	45.39	0.04
22.50	43.97		.16	44.21	- .01
22.99	43.51		.29	43.88	- .04
23.59	43.11		.35	43.55	.00
24.41	42.49		.44	43.01	- .01
24.72	42.24		.48	42.81	- .02
25.66	41.53		.62	42.25	.03
26.36	40.91		.73	41.74	.00
27.09	40.17		.87	41.14	- .05
28.32	39.06		1.14	40.31	.07
29.13	38.02		1.37	39.49	- .06

(a) With 2.0% HT present.

(b) Corrected to 0.0% HT.

TABLE II

SMOOTHED MOLAR DENSITIES OF LIQUID TRITIUM

T (°K)	ρ (mole/liter)	T (°K)	ρ (mole/liter)
20.62	45.35	25	42.65
21	45.12	26	41.98
22	44.52	27	41.26
23	43.91	28	40.48
24	43.29	29	39.66

ACCURACY

Error analysis shows the following possible contributions to $\rho_{liq} - \rho_{gas}$ values (first as direct units, then as error per cent): (a) missing a liquid level mark, 0.2 mm = 0.04%; (b) temperature of the bath, 0.003° = 0.005%- (c) temperature of the liquid tritium being above the bath temperature due to radioactive heat, 0.006° = 0.01%; (d) temperature in the gas measuring system, 0.1° = 0.03%; (e) pressure of the gas, 0.1 mmHg = 0.04%; (f) volume of the gas, 0.05 cc = 0.02%. These give a maximum error of $\pm$ 0.18% if additive or a "probable" error of $\pm$ 0.08% if random. The gas densities should be accurate to 0.1% in the best case (lowest temperature) and to 1% in the worst, contributing 0.000% and 0.04% errors, respectively. Finally, the HT correction should be reliable to 3%, contributing 0.01% error. Summarizing, the liquid density maximum error should be 0.23% for the worst case.